CURRENT MONITOR AND BEAM POSITION MONITOR PERFORMANCE FOR HIGH CHARGE OPERATION OF THE ADVANCED PHOTON SOURCE PARTICLE ACCUMULATOR RING*

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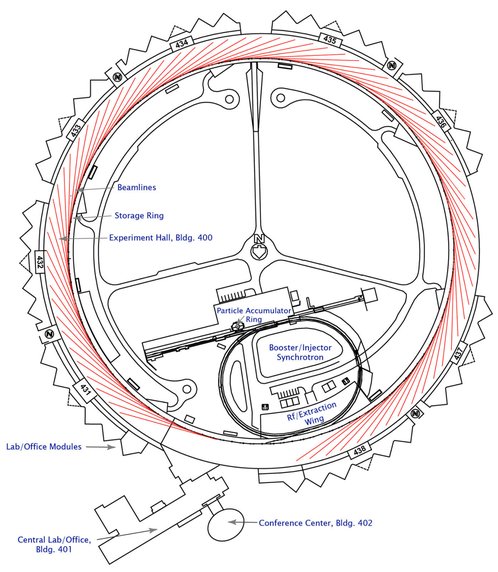
Abstract

A design choice for the Advanced Photon Source Upgrade (APS-U) to inject into the storage ring using bunch swap out rather than off-axis accumulation means that the Advanced Photon Source (APS) injectors are required to accelerate much higher electron bunch charge than originally designed. In the present work, we outline upgrades to the current monitor and beam position monitor (bpm) diagnostics for the Particle Accumulator Ring (PAR) to accommodate bunch charges of 1-20 nC. Through experiments, we compare and characterize the system responses over the range of bunch charge.

INTRODUCTION

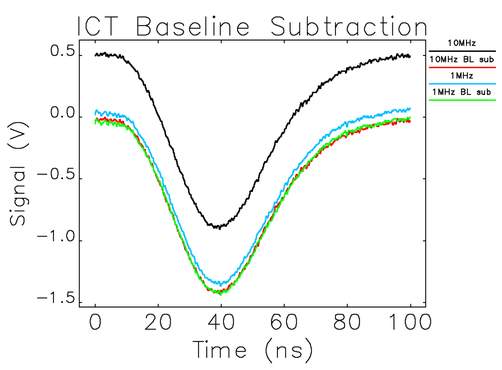
The APS-U will require the PAR to deliver up to 20 nC in a single bunch. The present APS PAR was designed to provide a maximum bunch charge of 6 nC at a 2-Hz repetition rate. To operate at the new target charge, an evaluation of the existing current monitor and bpm electronics was required.



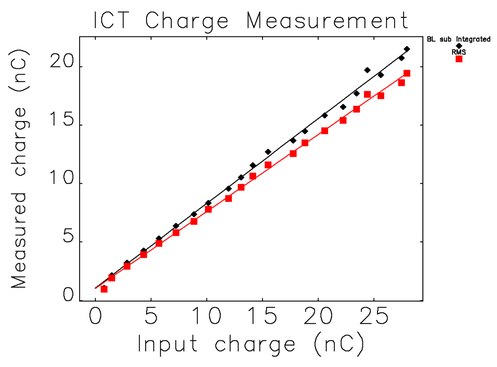
The Advanced Photon Source accelerator complex.

CURRENT MONITOR PERFORMANCE

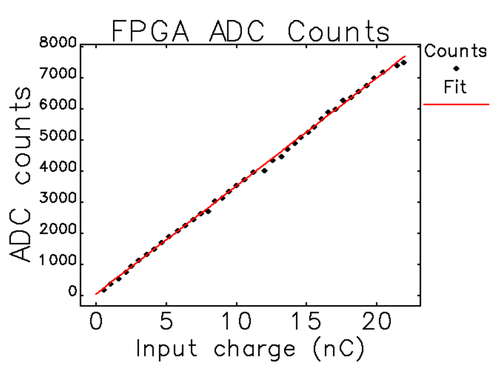
The PAR is equipped with an Integrating Current Transformer to measure charge. Due to the high revolution rate in the PAR (9.78 MHz), the output of the ICT becomes a baseline-shifted waveform rather than a single pulse. Measurements confirmed that the both the baseline-subtracted integrated and rms values of this waveform are proportional to the input charge. The existing FPGA-based data acquisition system was confirmed to be linear with input charge to over 20 nC.



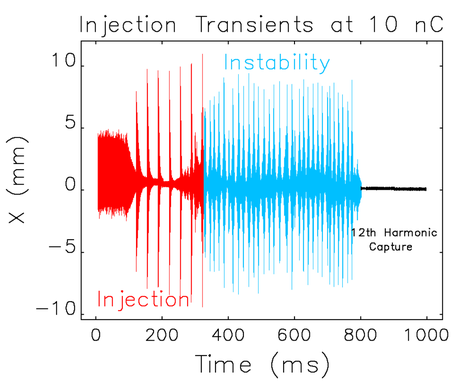
Measured ICT output waveform at 1 MHz and 10 MHz repetition rates. Subtraction of the baseline voltage shows that the waveform shape is nearly identical.



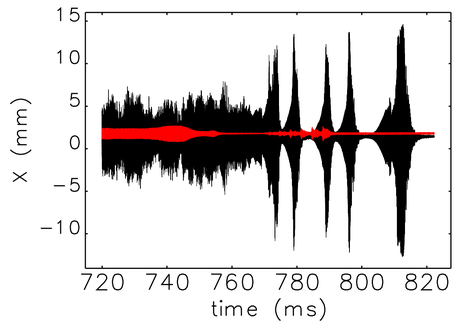
Measurement of charge by ICT at 10 MHz input pulse rate. The measured output charge is evaluated using both baseline subtracted integration and rms.



The relationship between input charge and ADC output counts for the FPGA-based data acquisition system is linear to beyond 20 nC.



Libera Spark ERXR turn-by-turn position data showing horizontal injection transients observed at 10 nC. Adjusting the orbit bump at the injection septum and the injection kicker settings reduced beam loss during injection.



Comparison of Spark bpm data at 10 nC. The black curve shows instability due to insufficient 12th harmonic cavity detuning. The red curve shows improved stability with sufficient detuning. The character of the instability changes as the 12th harmonic cavity turns on between 750 and 770 ms.

BEAM POSITION MONITOR PERFORMANCE

The existing PAR bpms provide a single position reading per injection cycle. To better understand the behavior of high-charge beam throughout the PAR cycle, the Libera Spark ERXR beam position processor was evaluated at two of the sixteen bpm locations. Using the turn-by-turn position data available from the Spark bpm, two causes of instabilities were identified. Mitigation of these instabilities resulted in achieving the target extracted charge of 20 nC per bunch.

CONCLUSIONS

The existing PAR current monitor and data acquisition system have a linear response over the full range of charge. The existing beam position monitor electronics require an upgrade to provide more detailed information about beam position, with the Libera Spark ERXR as a viable candidate for a comprehensive PAR bpm upgrade.

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